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Die Head for an Extruder

The invention is directed to a die head for an extruder comprising an outer shell, an inner cylindrical mandrel, an annular die gap located at discharge side, an intake opening located at an intake side for the melted mass, at least one distribution element for distributing the melted mass in a central ring channel merging into the die gap.

From DE 199 23 973 A1, a die head for an extruder is known, which essentially is comprised of an outer shell and an inner cylindrical mandrel. The shell as well as the mandrel are formed of segments, each having insert members for routing the inflowing melted mass from the intake side through a central ring channel, which merges into a die gap on a discharge side of the die head. Inside the die head, the melted mass is essentially spirally guided before it terminates, under pressure, in an axial direction through a die gap.

It is the object of the present invention to further develop a die head for an extruder such that it provides a more homogeneous melted mass as well as an extrudate that is free of joint lines and flow marks.

To meet this objective, the invention with the preamble of patent claim 1 is characterized in that the distribution element and/or an inflow channel are formed such that due to the inflowing melted mass, the distribution element is set into torsional motion around the longitudinal axis of the mandrel, and the flow of melted mass is routed to the central ring channel.

The particular benefit of the invention is a more homogeneous melted mass as well as extrudates that are free of joint lines, whereby an intensive agitation of the melt takes place. Surprisingly, it was found that a distribution element could be set into torsional motion by the melted mass flowing tangentially to its periphery due to the viscous drag effect of the melted mass sticking to the walls of the distribution element.

In a further embodiment of the invention, the distribution element can be of annular shape. However, polygonal shapes can also be employed, which preferably have a peripheral surface that resembles a ring.

Preferably, a thrust force resulting from the material expansion of the melted mass after emerging from the orifices of the distribution element is utilized to support the outer drag moment during the rotation of the distribution element. Inside the inner circular ring segment, the individual flows of melted mass, which are divided by orifices, are positioned on top of each other in a radial direction as a result of the rotation of the distribution element, and are routed inside the central ring channel to the die gap.

In a further embodiment of the invention, the distribution element includes a plurality of lamellae with interspersed orifices, which are arranged at a slant such that the forces resulting from the material expansion at the orifice exits facing the inner annular segment generate a thrust moment. The outer drag moment and the inner thrust moment add up favorably to a total torsional moment. Beneficially, the required torque can be generated in this way to overcome the friction resistances and to set the distribution element into rotation, namely, around the symmetrical axis of the mandrel.

In a further embodiment of the invention, at least one inflow channel extents in a tangential direction along a peripheral segment of the distribution element. Due to the tangential inflow of the melted mass, particularly of the partial melt flows, to the distribution element, a drive torque for rotating the circular ring element can be beneficially generated.

In a further embodiment of the invention, an inflow channel engages with an outer peripheral segment of the distribution element so that as large a peripheral surface (effective area) of the distribution element as possible is affected by the tangentially-oriented flow of melted mass. One end of the inflow channel extends thereby within close proximity to the outer periphery of the distribution element.

In a further embodiment of the invention, the height of the inflow channels can be equal to the height of the distribution element; however, it is preferred that the height of the inflow channel increases along the tangential course of the inflow channels. In this way, a flow direction that is tangential to the periphery of the distribution element can be achieved.

In a further embodiment of the invention, the outer periphery of the distribution element is engaged by at least one inflow channel. The lamellae of the distribution element are arranged such that the melted mass flowing tangentially to the rotor periphery thereby forming an obtuse angle passes from the outer periphery of the distribution element into an area inside the distribution element, subsequently to be routed via an inner annular segment to a central ring channel.

In a further embodiment of the invention, the shell is formed in segments, whereby shell segments and distribution elements are stacked on top of each other. In this manner, a coextrusion in particular can be generated. Alternatively, the shell segments can be separate in order to beneficially move the pre-distribution of the melted mass to the separation planes of the shell segments. In this manner, the tool-related part of the melt infeed required for the coextrusion can be realized in a beneficial manner.

A detailed description of one embodiment is given hereinbelow illustrated by the drawing, wherein:

Fig. 1 is a longitudinal section of a die head;

Fig. 2 is a cross section of the die head;

Fig. 3 is a partial longitudinal section of a die head according to an alternative embodiment;

Fig. 4 is a top view of the distribution element;

Fig. 5 is a longitudinal section of a distribution element according to a preferred embodiment in Fig. 4; and

Fig. 6 is a longitudinal section of a die head according to a further alternative embodiment.

A die head 1 is essentially comprised of an outer shell 2 and an inner cylindrical mandrel 4. Additionally, according to the invention, a distribution element 6 is provided in an area between the shell 2 and the mandrel 4, which around its periphery is surrounded by inflow channels 16.

Particularly for forming multilayered tubes, but also for the sheathing of string-shaped semi-finished products, at least one intake opening for the melt flows to be distributed are arranged on the exterior shell surface of the die head.

In the instant exemplary embodiment, the die head 1 is segmented in an axial direction and is comprised of a plurality of shell segments 2', each of which having a dedicated distribution element 6. The die head 1 is particularly suited for forming a coextrusion. As can be seen in Fig. 1, each of the shell segments 2' has intake openings 15, from which inflow channels 16 extend in the direction of the distribution element 6. After a melt flow, that is, partial melt flows 8, 8', and 8", pass through the orifices 7 of the distribution element 6, they are routed along a central ring channel 17 and along the mandrel 4 to a die gap 19 arranged on an discharge side 18. On the discharge side 18 as well as on an intake side 20 of the die head 1, cover plates 3 are provided, which press the shell segments 2' together, that is, with which the shell segments 2' are bolted together. In a first shell segment 2' facing the intake side 20, a first melt flow 8' of a first synthetic material is conveyed to the central ring channel 17. In the subsequent shell segment 2' in the direction of the flow, the plastic melt 8" of a different material is feed, via an intake opening (not shown) arranged laterally to the die head 1 and peripherally adjacent to the first plastic melt 8', through the central ring channel 17. Additional shell segments 2' and/or distribution elements 6 can follow in the

direction of the mandrel 4, whereby laterally, further melt flows of identical or different material can be introduced.

To produce a homogeneous melt – as can be better seen in Fig. 2 – a distribution element 6 is provided, which extends at a radial distance from the mandrel 4 in the area of an interior surface of the shell 2, that is, the shell segment 2'. Preferably, the distribution element 6 has an annular arrangement, with a plurality of lamellae 11 interspersed with orifices 7. The lamellae 11 can be tapered towards the inside. Preferably, the lamellae 11 are pointed or rounded towards the interior of the distribution element 6, whereby inert zones and the negative effects resulting therefrom, for example, long dwelling times, swirling etc. are avoided. The surfaces of the lamellae 11 forming the orifices 7 can thereby be planar or convex-shaped. The cross section of the orifices 7 can narrow in the direction of the flow, or can remain constant. A base area 71 of the orifices 7 can be planar or can have a radius, and/or can be horizontal or tilted towards the inner periphery of the distribution element 6.

As can be seen in Fig. 2, three inflow channels 16 are dedicated to the distribution element 6 such that respective viscous flows 81 are formed extending tangentially to the peripheral surface of a distribution element 21. The inflow channel 16 extends such that it engages the peripheral segment 21 of the distribution element 6. In the instant exemplary embodiment, the peripheral segment 21 engaged by the inflow channel 16 covers an angle of about 120 degrees. The inflow channel 16 narrows in a radial direction in the area of the peripheral segment 21 of the distribution element 6 until the end 22 of the inflow channel 16 reaches the vicinity of the outer periphery of the distribution element 6, without touching said outer periphery. The end 22 of the inflow channel 16 extends within close proximity to a succeeding inflow channel 16`. In this way, the drag effect of the flow of melted mass 81 extending tangentially to the distribution element 6 is transmitted to a maximum peripheral surface 21 of the distribution element 6, whereby the drag moment generated at the periphery of the distribution element 21 by the wall-adhering melt flow 81 is maximized. In addition, a more homogeneous supply of

the partial melt flow 8 to the outer peripheral area of the distribution element 6 is assured.

The maximum height H of the inflow channel 16, which preferably is reached at the end 22 of the inflow channel 16, corresponds to the height H of the distribution element 6. Preferably, the height h of the inflow channel, starting at the inflow point 161 of the inflow channel 16, increases to the height H of the distribution element 6 at the end 22 of the inflow channel 16. Due to the steady expansion from an initial height h of the inflow channel all the way to the height H of the inflow channel at the end 22 of the inflow channel 16, the viscous flow 81 required for the rotation of the distribution element 6, which causes drag moments and extends tangentially to the peripheral segment 21 of the distribution element 6, is beneficially intensified on the one hand, and on the other hand, a particularly homogeneous distribution of the melted mass is achieved. The inner shell surface below and/or above the inflow channel 16 extending close to the distribution element 6, is preferably tilted and/or rounded, whereby an optimization in regard to inert zones to be avoided is achieved in a beneficial manner.

The lamellae 11 of the distribution element 6 are tilted in the same way such that partial melt flows 23 are rerouted from the inflow channel 16 through the orifices 7 into the inner cavity 24 of the die head 1, thereby passing over an obtuse angle ß. By arranging the orifices 7 in this way, the force action generated at the orifice exit 72 by the expansion of the melted mass is utilized with a lever arm 80 according to Fig. 4 to generate a thrust moment, which supports the rotation of the distribution element 6 in a direction 25 around the longitudinal axis of the mandrel 4. A drive torque is generated by the drag effect of the wall-adhering melted mass, which is caused by the melt flow of the inflow channels 16 extending tangentially to the periphery of the distribution element 6.

The base area 71 of the orifices 7 according to Figs. 4 and 5 can be planar or have a radius, and in its extension from the outer to the inner radius of the distribution element 6 formed as a circular ring, can be horizontal or tilted. Figs. 4

and 5 illustrate a preferred embodiment of the distribution element 6 having a base area 71 that is inclined such that the entire interior area 61 of the distribution element 6 is utilized for the discharge of the orifices 7. In this way, the force action predominant at the orifice discharge 72 and generating the thrust factor, which positively aids the torsional motion of the distribution element 6, can be extended across the entire inner surface of the distribution element 6. At the same time, the inner shell surface of the distribution element 6, which generates the braking torque, can be reduced to a minimum.

The lamellae 11 can be straight or curved. The lamellae 11 can be of uniform shape in the peripheral direction, or at regular intervals, can be of different shapes.

The melted mass can be a thermoplastic material, for example.

The distribution effect of the present invention can also be used for other free-flowing mediums.

In an alternative embodiment of a die head 31 according to Fig. 3 for forming a coextrusion, a shell segment 32 can have a plurality of annular hollow chambers 34 extending in a radial plane 33 away from the segment. For example, an outer hollow chamber 35 can be provided, in which a distribution element 36 having a relatively wide radius extends. In a radial direction to the inside, a first inner cavity 37 with a first inner distribution element 38 and an axially staggered second inner cavity 39 with a second inner distribution element 40 extend. The distribution elements 36, 38, 40 can be shaped like the distribution element 6 of the embodiment in Figs. 4 and 5.

The plastic melt is fed into the outer hollow chamber 35 via an axial intake opening 41 and a subsequent intake channel 42. The corresponding intake channels of the other hollow chambers 37 and 39 extend in the same fashion rotation-symmetric in a peripheral direction around the annular elements 38, 40.

However, the intake openings are arranged in a different peripheral area of the shell segment 32. At least one intake opening is dedicated to each of the hollow chambers 34, 37, 39, from which the intake channels 42 branch off symmetrically in relation to the longitudinal center plane of the die head 31, or rotation-symmetric. An even supply of the plastic melt to the corresponding hollow chambers 34, 37, 39 is necessary to assure a self-centration of the annular elements 36, 38, 40. The pre-distribution of a melt flow, which is routed in sideways via an orifice arranged at the peripheral area of the shell segment 32, can be done, for example, with multi-pronged distributors, center-sleeve distributors etc.

The distribution element is formed as a circular ring element having radial orifices, and routes the flow of melted mass to an inner circular ring segment, where the flow of melted mass is routed in an axial direction inside the central ring channel to the die gap.

For a punctiform merging of the plastic melt for coextrusion, a first discharge channel 43, which extends from a segment of the outer hollow chamber 35 facing the inner side of the circular ring element 36 to an annular junction point 44, is dedicated to the outer hollow chamber 35. A second discharge channel 45, which extends from the inside of the first inner hollow chamber 37, terminates at this annular junction point 44. A third discharge channel 46 originating in the second inner hollow chamber 39 also terminates at the annular junction point 44 so that various plastic melts can be stacked on top of each other.

Beneficially, coextrusion can hereby done in a space-saving manner because the hollow chambers 35, 37, 39 are essentially arranged in a radial plane 33. The hollow chambers 35, 37, 39 are all of annular shape, each having a single annular element 36, 38, 40 arranged inside.

In the instant exemplary embodiment, the die head 31 has a mandrel 47 that increases in width axially in the direction of the orifice 41, in which the inner hollow

chambers 37 and 39 as well as their dedicated annular elements 38 and 40, and the discharge channels 45, 46 are arranged. As an alternative, the mandrel 47 can be segmented.

In a preferred embodiment of the distribution element 6 of Figs. 4 and 5, the distribution element 6 functioning as a rotor is a circular ring element having a beveled inner ring surface 112. Thus, the distribution element 6 has lamellae 107, which widen radially towards the outside. The distribution element 6 is conical in its cross section. The distribution element 6 can be symmetrical to its longitudinal center plane 109. Beveling results in a wider distribution of individual flows of melted mass 110, preferably in a radial and/or axial direction. Before reaching the inner ring surface 112 of the distribution element 6, the individual flows of melted mass leave a channel 111 of the distribution element 6. The individual flows of melted mass 110 are thereby separated in an axial and/or radial direction. Thus, the emerging individual flows of melted mass 110 can be wider in a radial and axial direction, therefore being more effective. In this manner, the effect of joint line obliteration and material homogenization resulting from the rotor torsion can be reinforced. Additionally, the loss of pressure in the distribution element 6 is substantially reduced. The result is a multi-layer melt flow medley. Due to low resistance, the speed of the individual melt flows 110 arranged at a distance to the center line 109 is greater than the speed of the individual melts 110 flowing along the base areas 71 of the orifices. The lamellae 11 on a first face side 150 and an opposite face side 151 of the distribution element 6 are staggered such that one lamella 107 each is positioned above an orifice 7. Preferably, the lamellae 107 are tapered towards the interior of the distribution element, or else are rounded. With a design and array of the lamellae 107 such as this, a considerable improvement of the properties of the semi-finished product with regard to a high quality of the extrudate can be achieved, for example, pipes and foils free of joint lines, improved mechanical and optical properties of the extrudate.

The channels 111 can be curved of rounded. Possible sharp edges of the channel 111 can be rounded. All surfaces of the distribution element 6 can be

cambered surfaces; the strength of the ring wall, the diameter and height of the distribution element 6 can be varied.

The wall strength, diameter and height of the distribution element 6, preferably a circular ring element, can be varied such that the sum of the torques driving the distribution element, comprised of the drag and thrust moments, is greater than the friction moments caused by the viscosity of the melt.

In an alternative embodiment of the die head 2032 according to Fig. 6 for tube extrusion of thermally sensitive melts, for example, PVC, a shell segment 201 can include a displacement body 202, which on the side facing the melt intake opening 203 is conical or torpedo-shaped. The displacement body 202 is supported by a cover plate 204 located opposite the intake opening 203. Extending along the side of the displacement body 202 facing the nozzle discharge 205 is an annular hollow chamber 206, wherein again a distribution element 6 according to Figs. 4 and 5 is arranged. Due to a plurality of melt-conveying inflow channels 207 similar in design to the inflow channels 16, and the distribution element 6, the drag and thrust moments resulting from the beneficially arranged melt routing are likewise utilized for the rotation of the distribution element 6.

The inflow of melted mass can be conveyed to the distribution element either from the outside and/or from the inside. An in a radial direction exterior outer peripheral surface of the distribution element and/or an in a radial direction interior inner peripheral surface of the distribution element is thereby impacted by the melt.